Activities of Climate Forecasting Unit

CFU team, IC3, Barcelona

Eleftheria Exarchou

10 November 2014

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SEVENTH FRAMEWORK PROGRAMME

SPECS

Seasonal-to-decadal climate Prediction for the improvement of European Climate Services

PREFACE

CFU Team

- ***Francisco J Doblas-Reyes***
- ***Muhammad Asif: EC-Earth***
- ***Pierre-Antoine Bretonnière: SPECS data***
- ***Louis-Philippe Caron: tropical cyclones***
- ***Melanie Davis: climate services***
- ***Neven Fuckar: Arctic sea ice***
- ***Virginie Guémas: sea ice, XXIst century hiatus***
- ***Omar Bellprat: extreme events***
- ***Domingo Manubens: autosubmit developer***
- ***Oriol Mula-Valls: system administrator***
- ***Aida Pintó: prediction of extremes***
- ***Chloé Prodhomme: Sources of seasonal skill***
- ***Mar Rodríguez: SPECS manager***
- ***Luis Rodrigues: seasonal climate predictability***
- ***Gabriela Tarabanoff: secretary, climate services***
- ***Verónica Torralba: climate services***
- ***Nube Gonzalez-Reviriego: climate services***
- ***Danila Volpi: initialisation, decadal prediction***
- ***Nico Manubens: s2dverification developer***
- ***Eleftheria Exarchou: Analysis of drift and bias***
- ***Martin Ménégoz: Volcanic aerosols***

Objectives:

1) ***Development of s2d prediction capability***
2) ***Forecast quality assessment***
3) ***Downscaling of probabilistic forecasts***
4) ***Climate services***

We share on request:

1) ***Autosubmit***
2) ***Sea-ice restarts***
3) ***s2dverification R package***

We run on:

1) ***Marenostrum (Spain)***
2) ***ECMWF***
3) ***Lindgren (Sweden)***
4) ***ARCHER (UK)***
5) ***Our local cluster (Ithaca)***

National and international projects

European Commission:

1. QWeCI : Climate and Health over Africa
2. CLIM-RUN : Climate information - Mediterranean region
3. DENFREE : Dengue
4. SPECS : Seasonal-to-Decadal predictions
5. EUPORIAS : Climate services
6. IS-ENES2 : Infrastructure for Earth System Modelling
7. PREFACE : Tropical Atlantic climate and fisheries
8. EUCLEIA : Attribution of extreme events

Spanish Government:

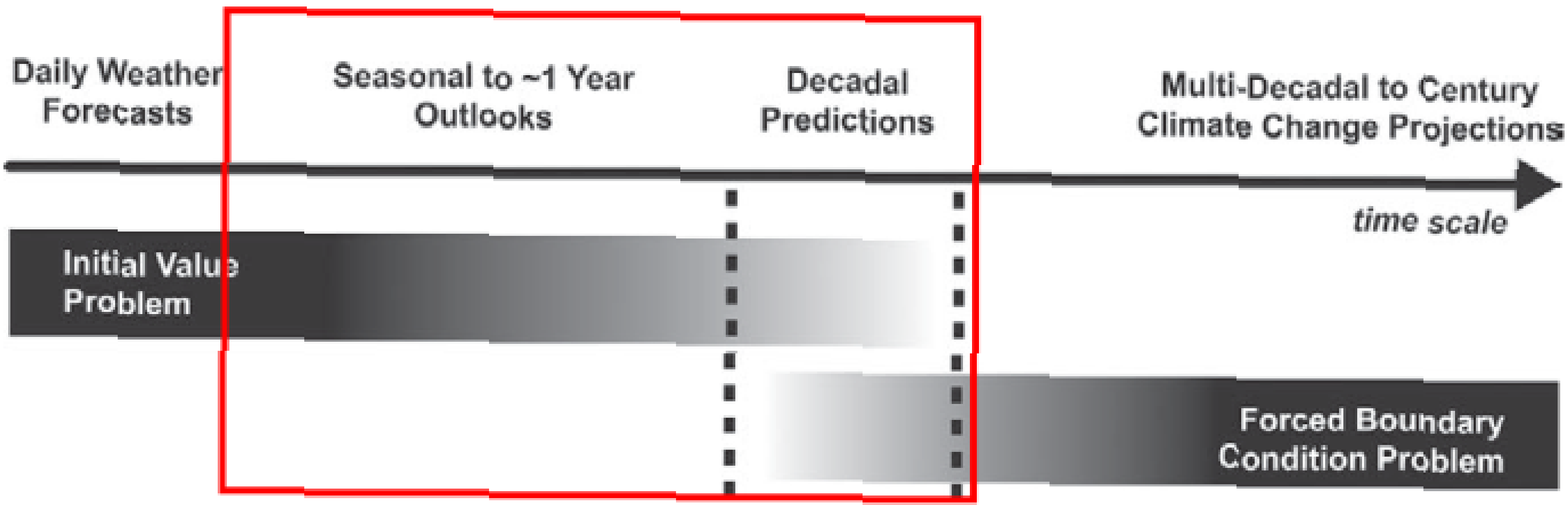
1. PICA-ICE : sea ice reconstruction and prediction
2. RESILIENCE : climate services – renewable energy
3. RUCSS : seasonal-to-decadal predictions

Others:

1. Private: RPI, MAPFRE, Banca Cívica
2. Agence Nationale de la Recherche (France).
3. German Academic Exchange Service

Climate time scales

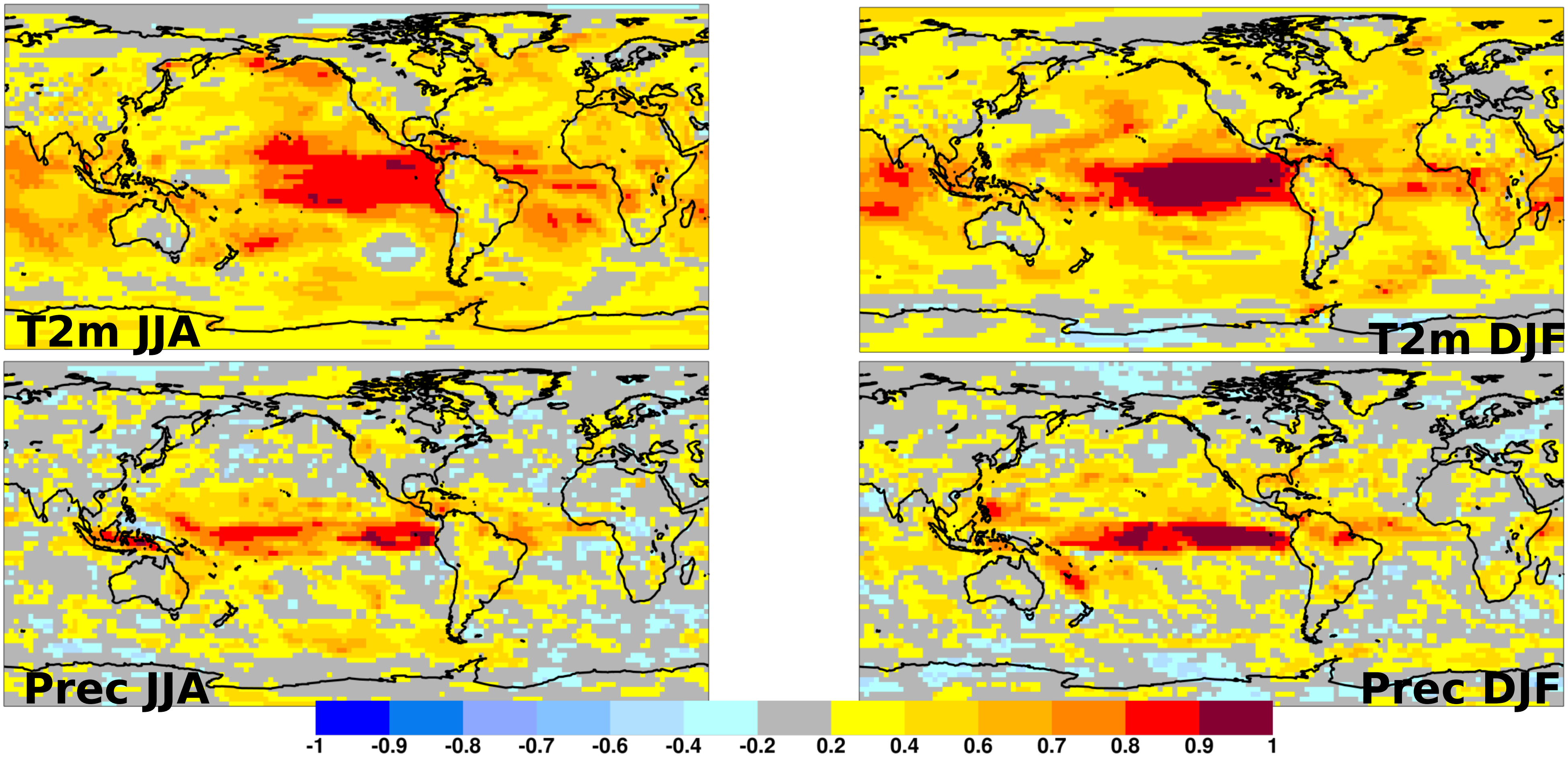
Progression from initial-value problems with weather forecasting at one end and multi-decadal to century projections as a forced boundary condition problem at the other, with climate prediction (sub-seasonal, seasonal and decadal) in the middle. Prediction involves initialization and systematic comparison with a simultaneous reference.



Meehl et al. (2009)

Typical seasonal forecast skill

Correlation of the ensemble mean for the ENSEMBLES multi-model (45 members) wrt ERA40-ERAInt (T2m over 1960-2005) and GPCP (precip over 1980-2005) with 1-month lead.



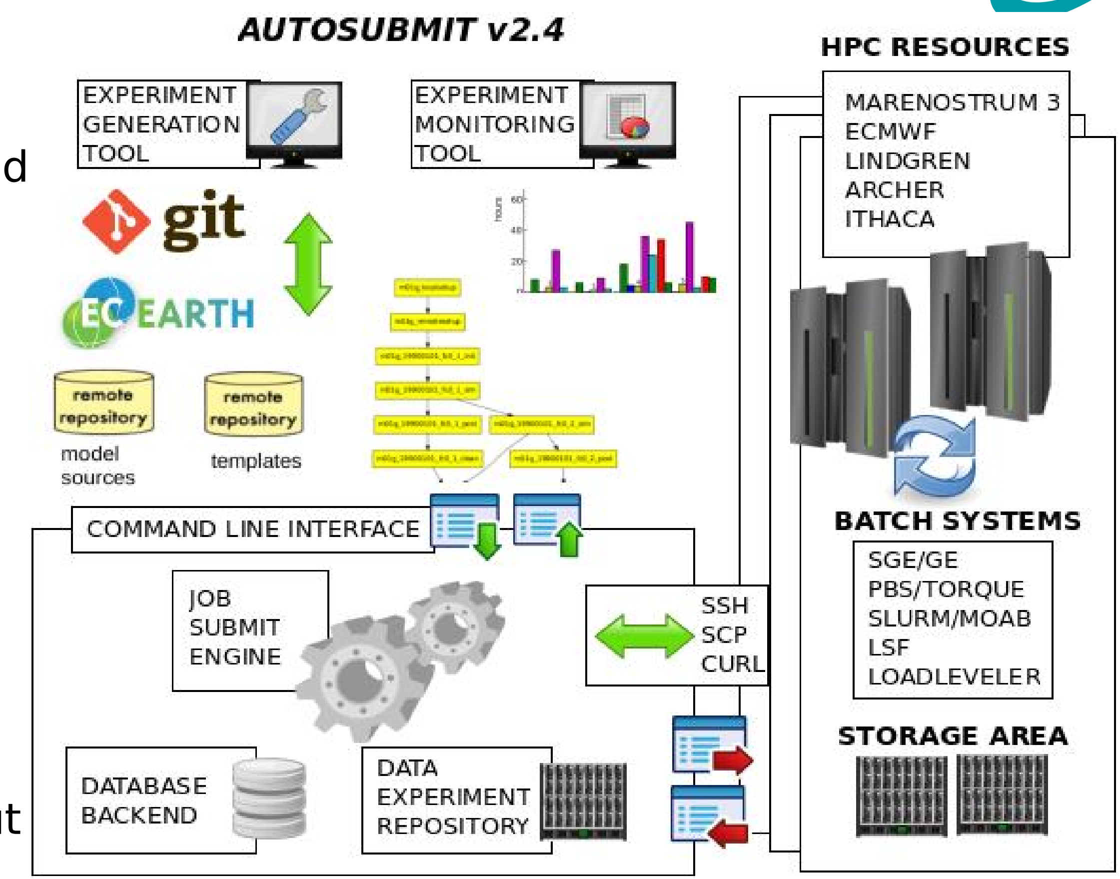
Some open fronts

- Work on initialisation: generate initial conditions (e.g. for sea ice, ocean). Compare different initialisation techniques (e.g. full field versus anomaly initialisation)
- Calibration and combination: empirical prediction (better use of current benchmarks), local knowledge.
- Forecast quality assessment: scores closer to the user, reliability as a main target, process-based verification.
- Improving model processes: Inclusion and/or testing of model components: biogeochemistry, vegetation, aerosols, sea ice
- More sensitivity to the users' needs: going beyond downscaling, better documentation (e.g. use the IPCC language), demonstration of value and outreach.

Autosubmit

Autosubmit acts as a wrapper to run a climate experiment on a HPC. The experiment is a sequence of jobs that it submits, manages and monitors. When a job is complete, the next one can be executed.

- Divided in 3 phases: ExpID assign, experiment creation, run.
- Separation experiment/autosubmit cod
- Config files for autosubmit and experiment.
- Database to store experiment information.
- Common templates for all platforms.
- Recovery after crashes.
- Dealing with a list of schedulers and communication protocols.

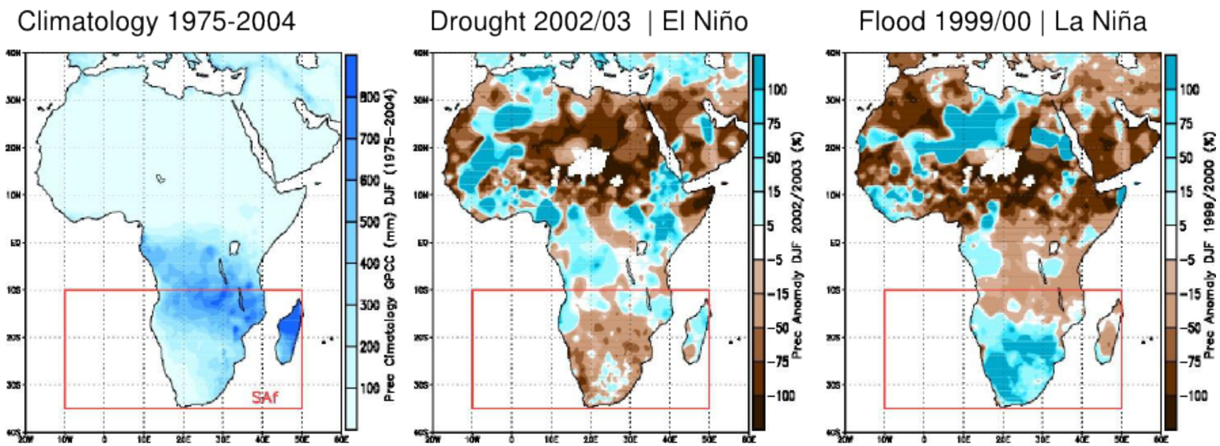


http://ic3.cat/wikicfu/index.php/Tools/Autosubmit

Domingo.manubens@ic3.cat

Attribution of extreme events

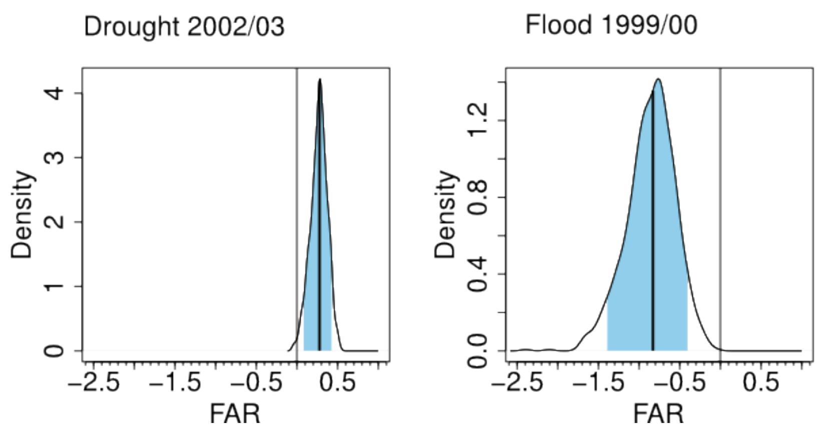
How has anthropogenic activity changed the odds of extreme events?



Southern African drought (2002/2003) and flood (1999/200)

Fraction of attributable risk $FAR=1-P_{all}/P_{NAT}$

$P_{all,nat}$=Probability of exceeding the event using all forcings and natural forcings only.



Climate change has increased the risk of dry winter seasons and reduced the risk of wet winter seasons.

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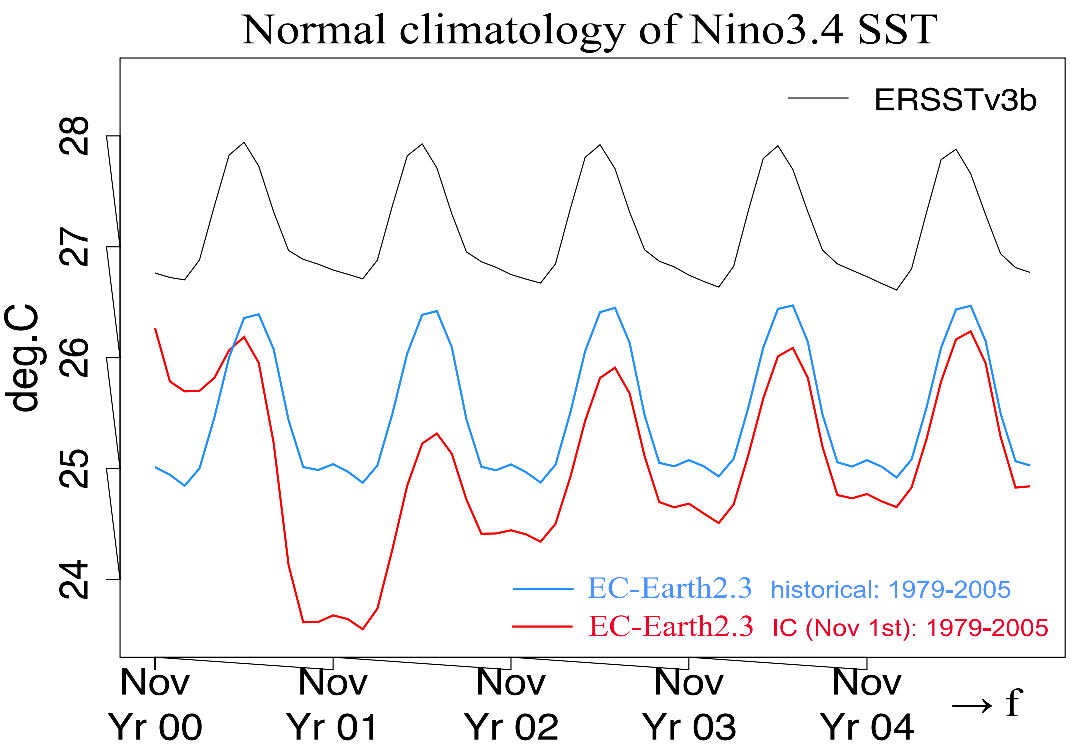
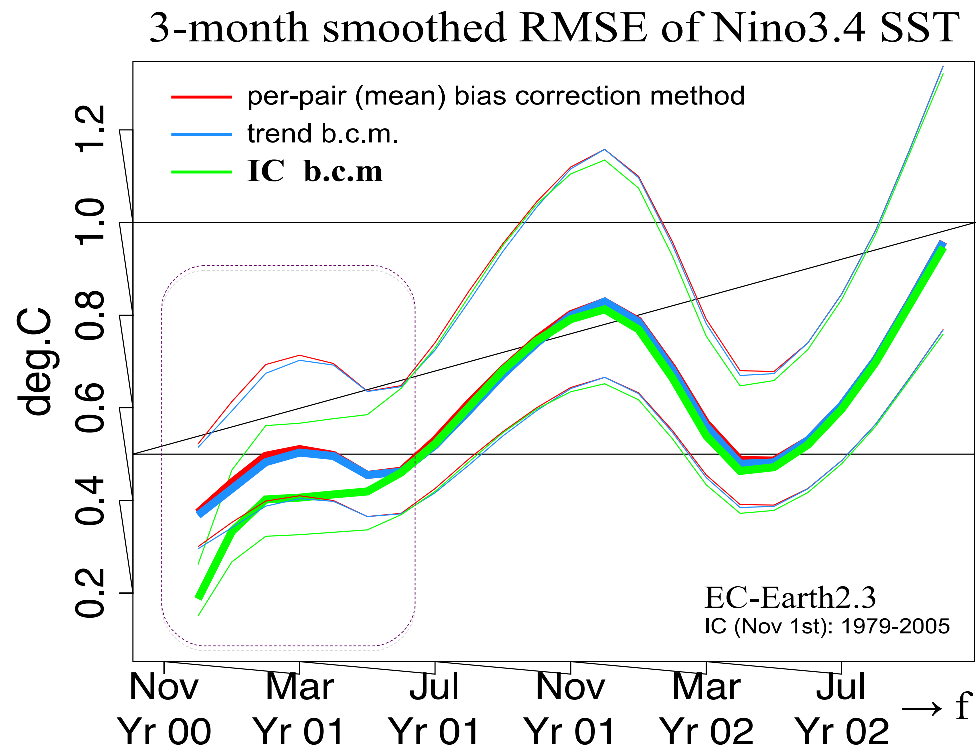
IC bias correction method (Fučkar et al., GRL 2014)

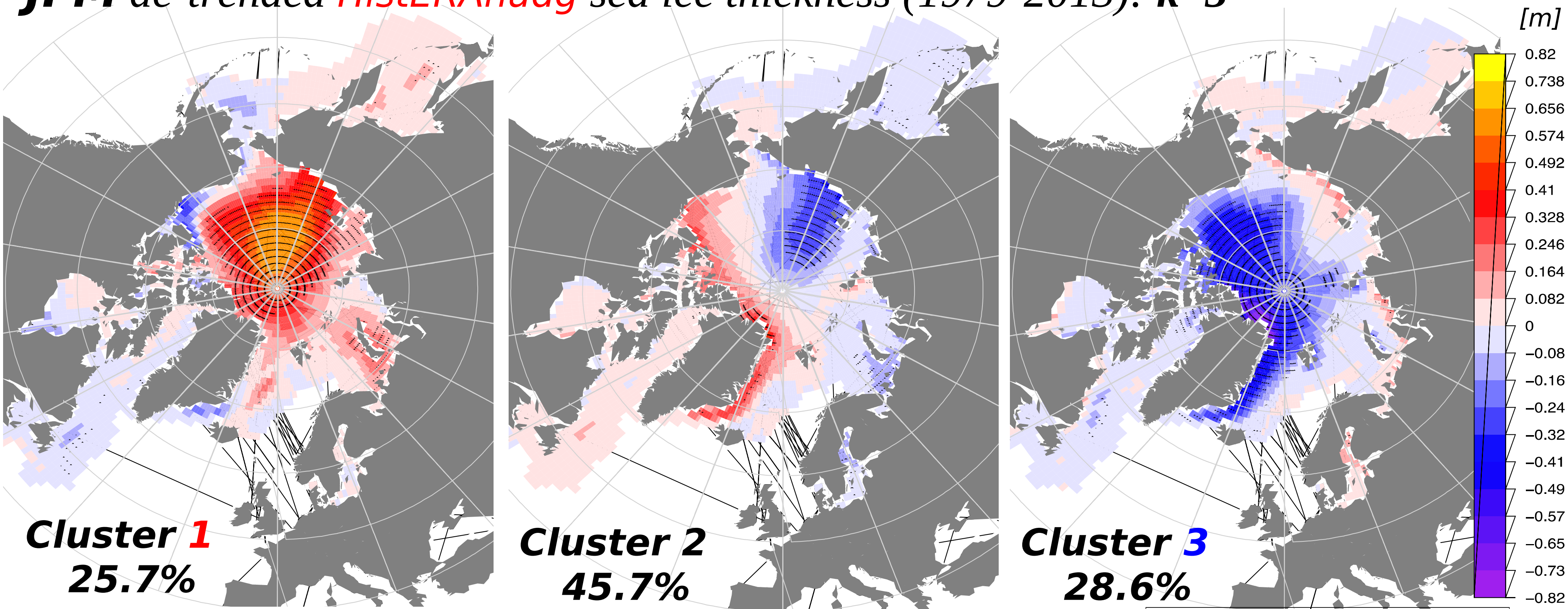


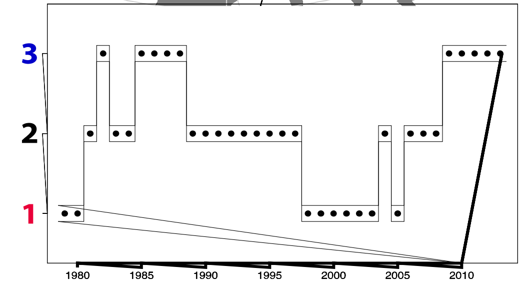


- ***IC bias correction method replaces the linear regression of monthly forecasts on smoothed proxy of OBS IC, here specifically OBS in the first forecast month $o_{i,1}$, with the linear regression of monthly OBS on $o_{i,1}$ for each forecast month f. i=start date***

The k-means cluster analysis of IC3 sea ice reconstruction

JFM *de-trended HistERAnudg sea ice thickness (1979-2013):* ***k=3***





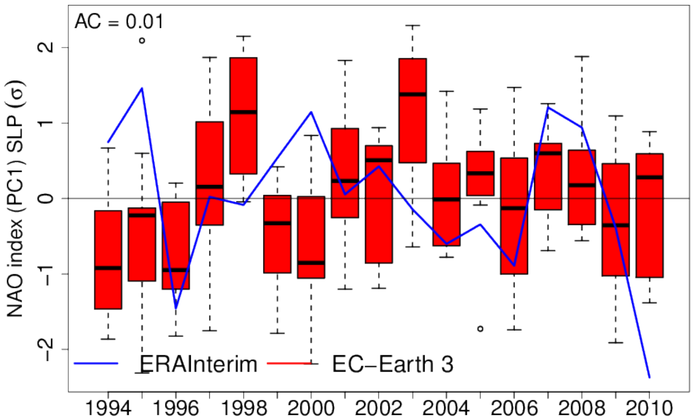
JAS cluster patterns have very similar structures

Fučkar et al. (in preparation)

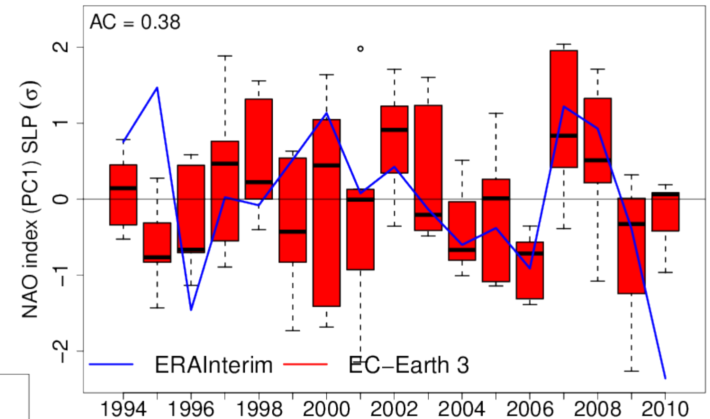
Predicting NA atmospheric circulation

Predictions of DJF NAO with **EC-Earth3 low and high resolution** and ECMWF S4 started in November over 1993-2009 with ERA-Interim and GLORYS initial conditions and five-member ensembles. Correlation of the ensemble mean on top left.

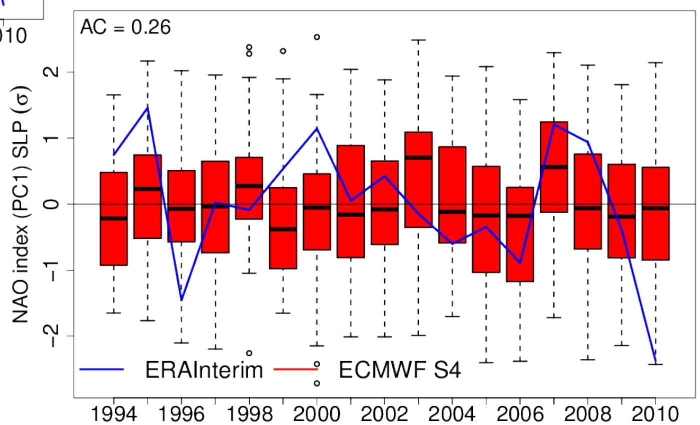
EC-Earth3 T255/ORCA1



EC-Earth3 T511/ORCA025



ECMWF S4

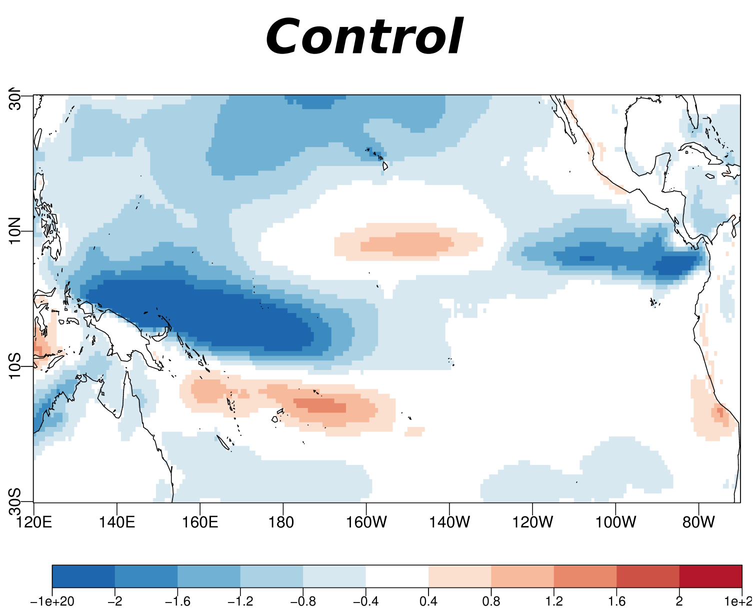


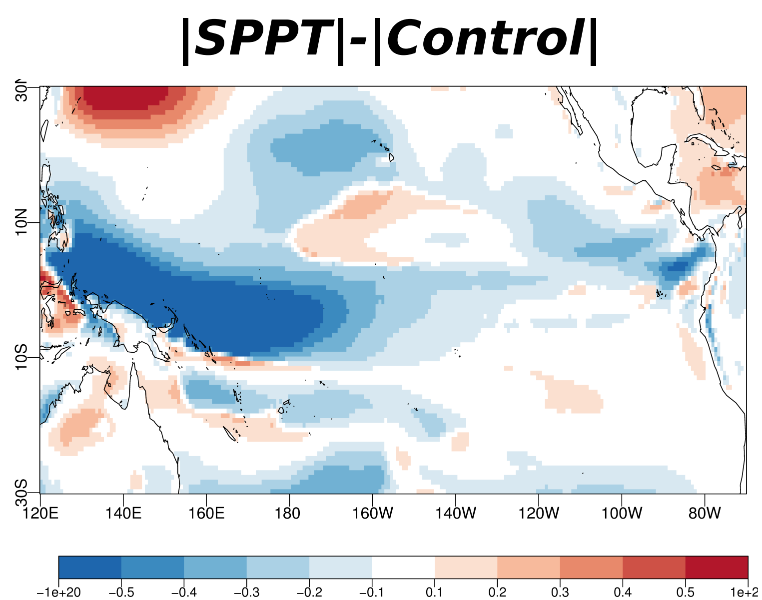
Batté et al. (2014)

HiResClim

Stochastic perturbations

DJF one-month lead time bias for the 10-metre zonal wind (m/s) from EC-Earth3 T255/ORCA1 hindcasts over 1993-2009 (10-member ensembles) with the standard forecast system and with SPPT. Other improvements in probabilistic scores. (blue = reduction in bias).

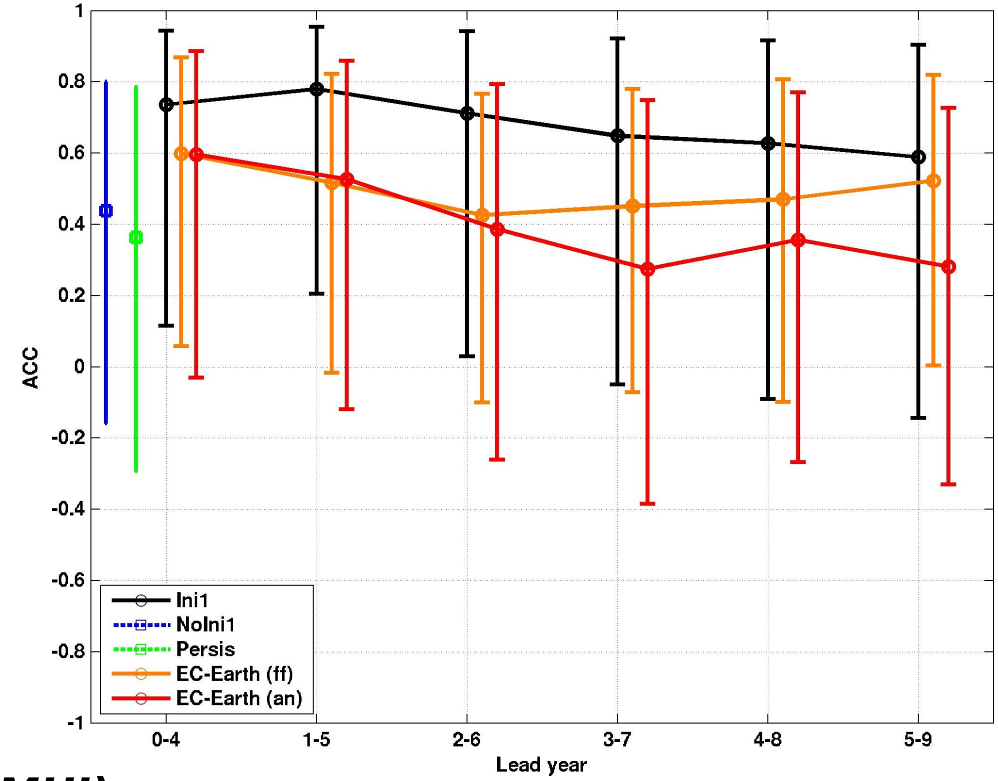




L. Batté (Météo-France)

Hurricane frequency prediction

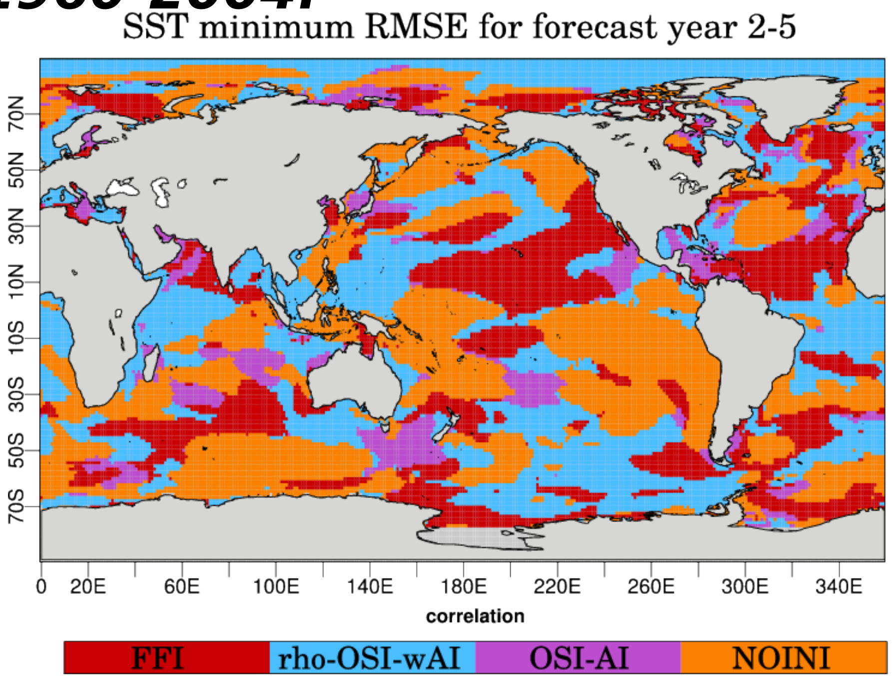
Average number of hurricanes per year estimated from observations and from EC-Earth decadal prediction (forecast years 1-5). The correlation of the ensemble mean for the initialized, uninitialized and statistical predictions are shown with the 95% confidence intervals.

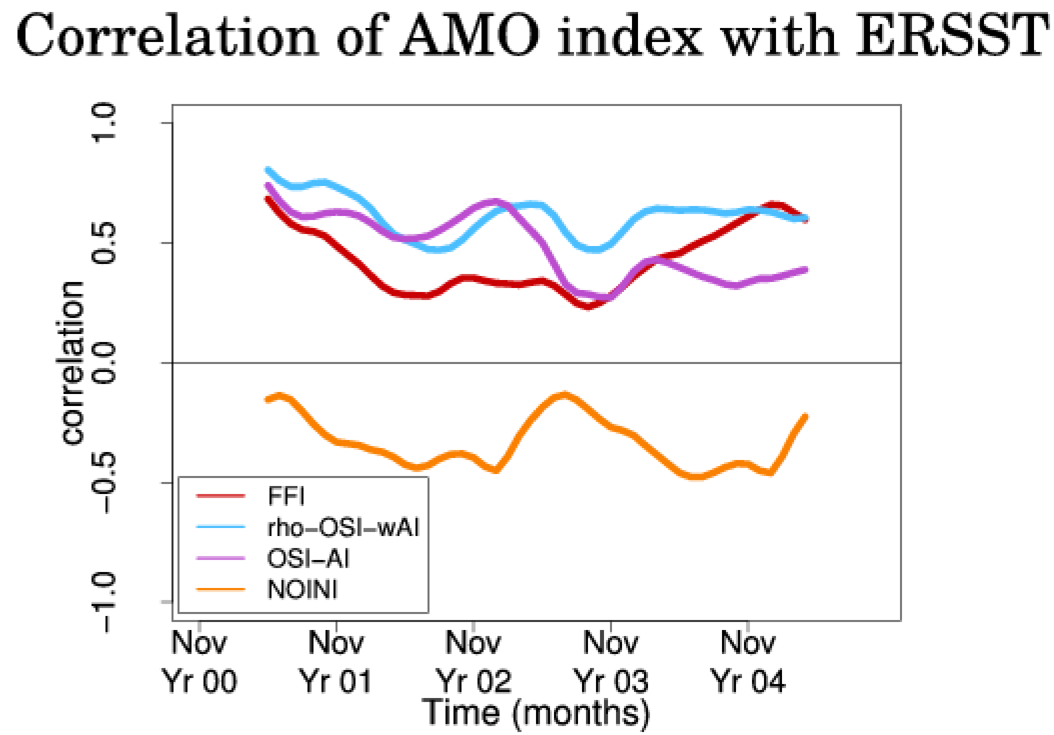


L.-P. Caron (IC3/SMHI)

Full-field versus anomaly initialisation

Comparison between full-field and anomaly initialisation experiments with EC-Earth2.3: FFI full-field initialisation, OSI-AI anomaly initialisation for ocean and sea ice, rho-OSI-wAI anomaly initialisation for ocean and sea ice with weighted anomaly and anomalies in T and density (instead of T and S). Five-member experiments for five years and start dates every 2 years over 1960-2004.

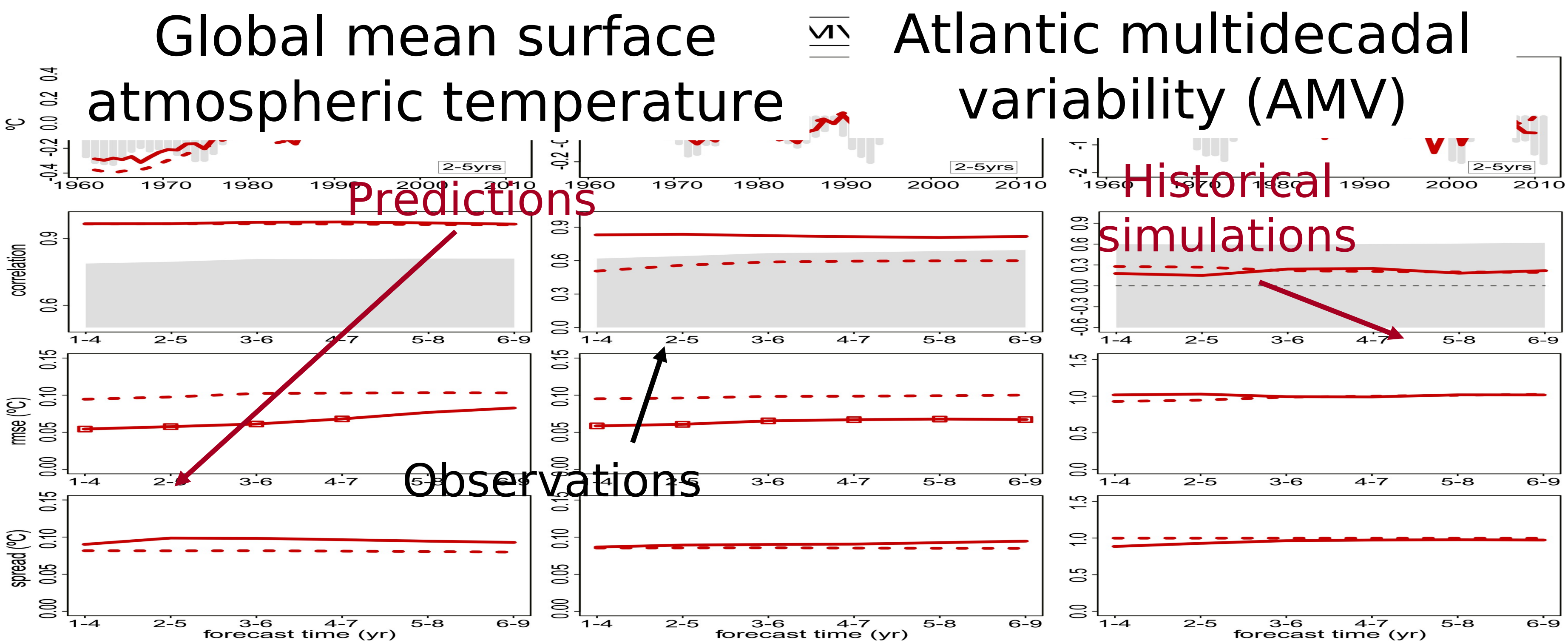




D. Volpi (IC3)

CMIP5 decadal predictions

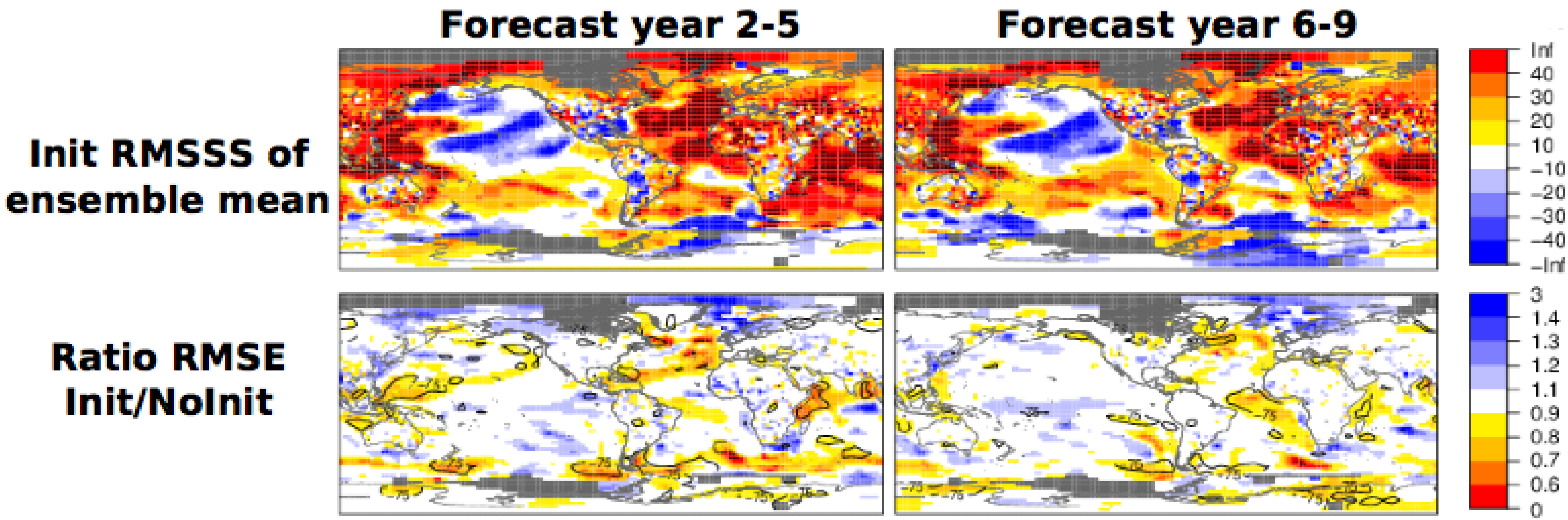
CMIP5 decadal predictions. Global-mean t2m and AMV against GHCN/ERSST3b for forecast years 2-5. **The initialised experiments reproduce the GMST trends and the AMV variability and suggest that initialisation corrects the forced model trend and phases in some of the internal variability.**



Doblas-Reyes et al. (2013)

Impact of initialisation in CMIP5

(Top row) Root mean square skill score (RMSSS) of the ensemble mean of the initialised predictions and (bottom row) ratio of the root mean square error (RMSE) of the initialised and uninitialised predictions for the near-surface temperature from the multi-model CMIP5 experiment (1960-2005) for (left) 2-5 and (right) 6-9 forecast years. Five-year start date interval.

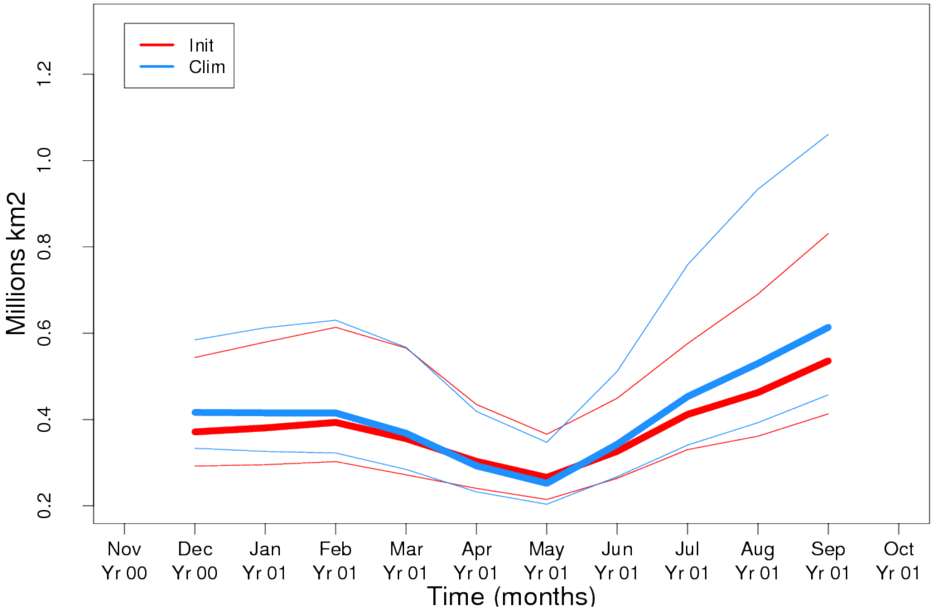


Doblas-Reyes et al. (2013)

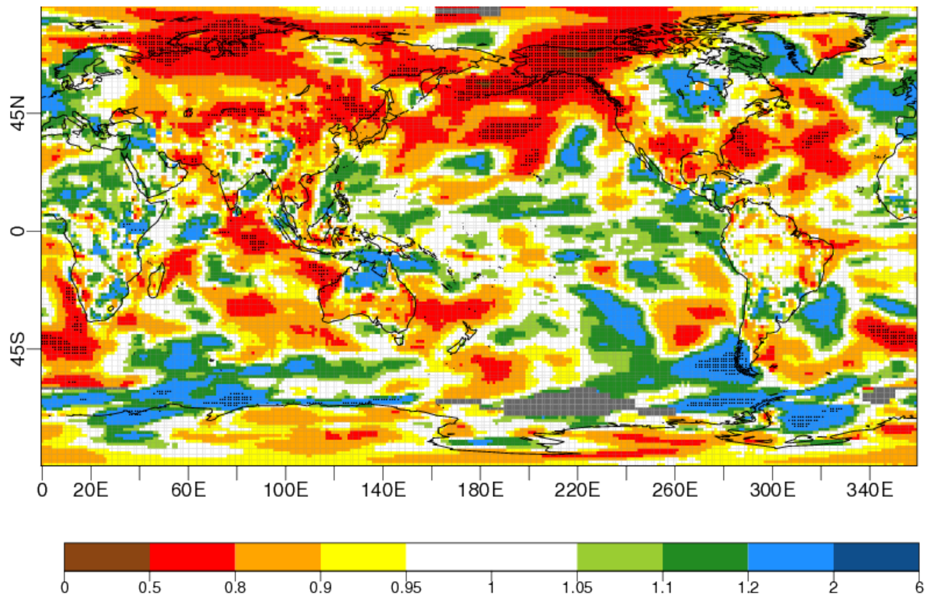
Impact of initialisation: Sea ice

Predictions with EC-Earth2.3 started every November over 1979-2010 with ERAInt and ORAS4 initial conditions, and a sea-ice reconstruction. Two sets, one initialised with realistic and another one with climatological sea-ice initial conditions. Substantial reduction of temperature RMSE in the northern high latitudes when using realistic sea-ice initialisation.

RMSE Arctic sea-ice area



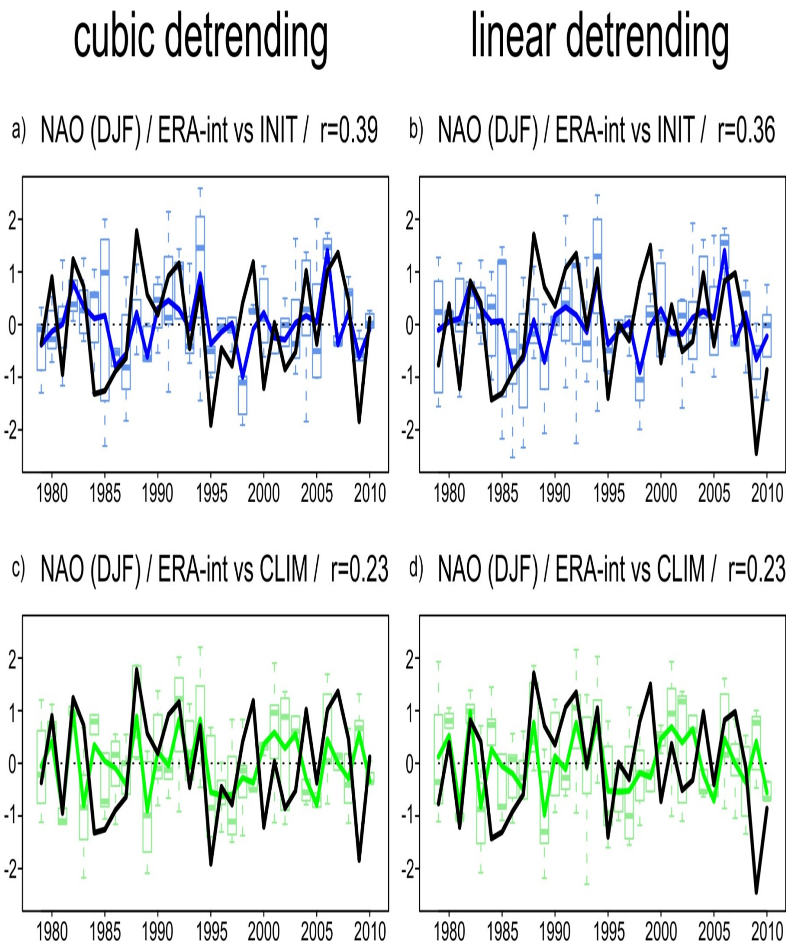
Ratio RMSE Init/Clim hindcasts 2-metre temperature (months 2-4)



Guemas et al. (2014)

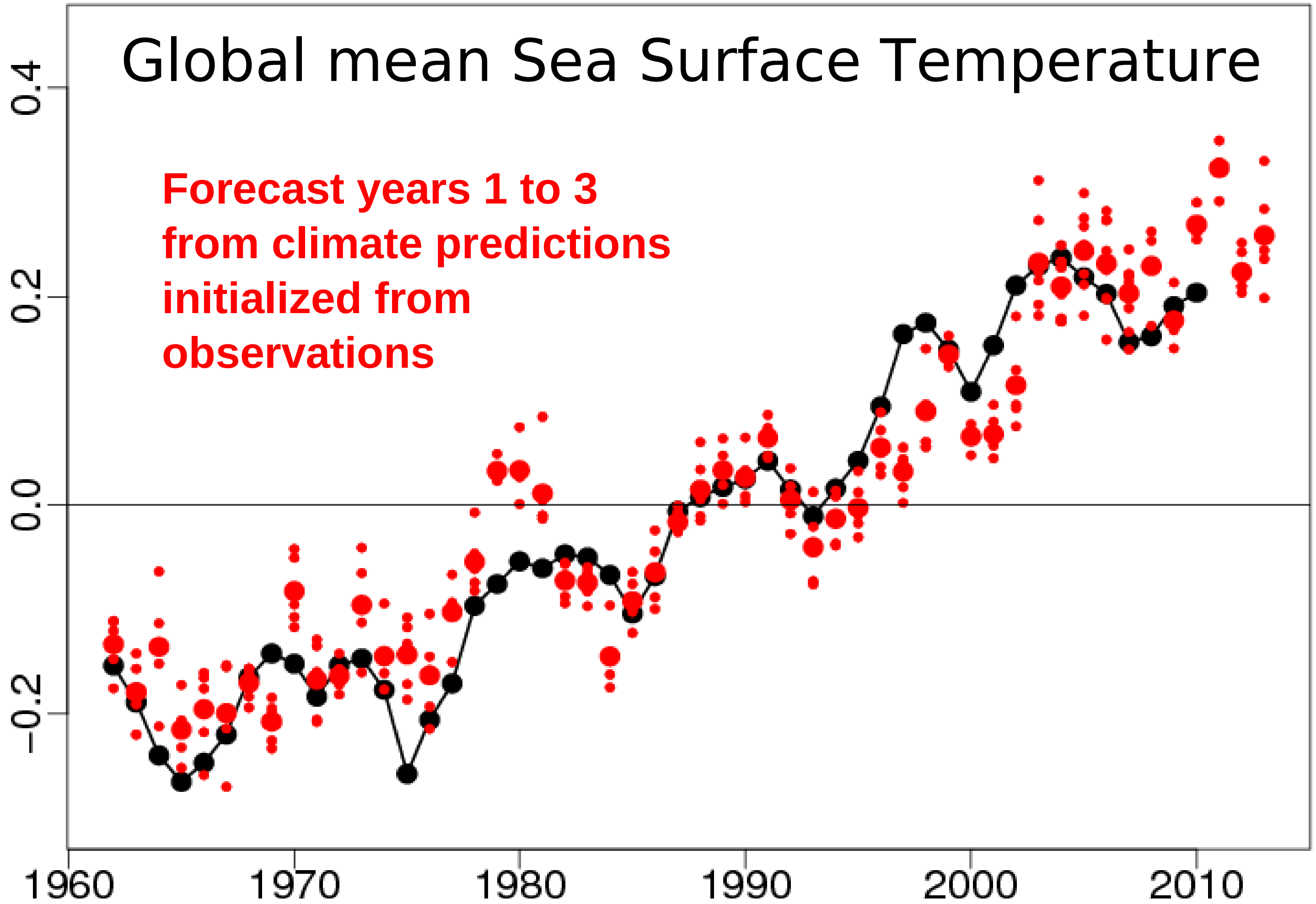
Predicting NA atmospheric circulation

Predictions of DJF NAO with EC-Earth2.3 started in November over 1979-2010 with ERAInt and ORAS4 initial conditions. Two sets, one initialised **with realistic (top) and one with climatological (bottom) sea-ice initial conditions**.



J. García-Serrano (IPSL)

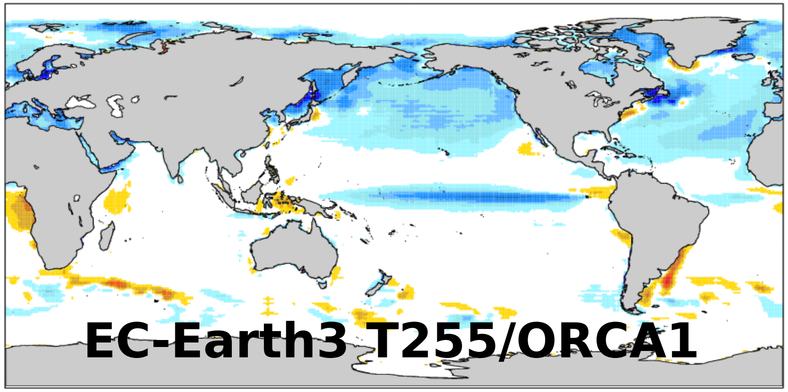
Predictions of hiatus

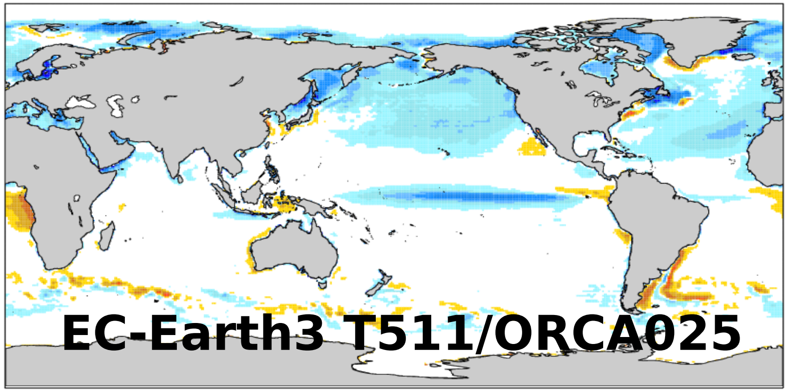


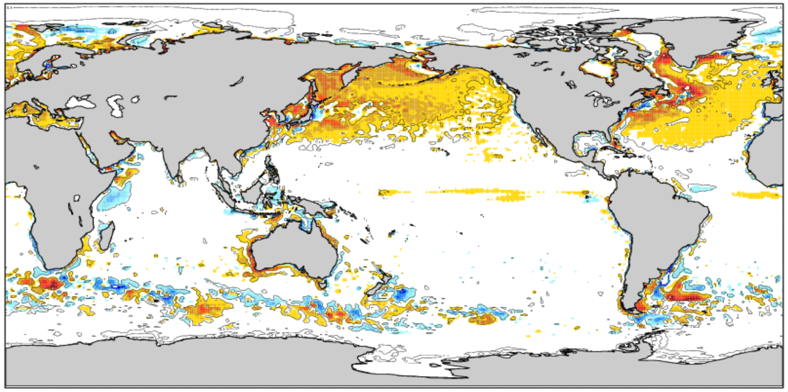
Guemas et al. (2013), Nature Climate Change

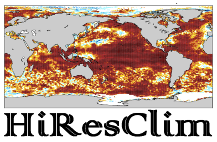
Increase in resolution: mean climate

Mean SST (K) systematic error versus ERAInt for JJA one-month lead predictions of EC-Earth3 T255/ORCA1 and T511/ORCA025. May start dates over 1993-2009 using ERA-Interim and GLORYS initial conditions.





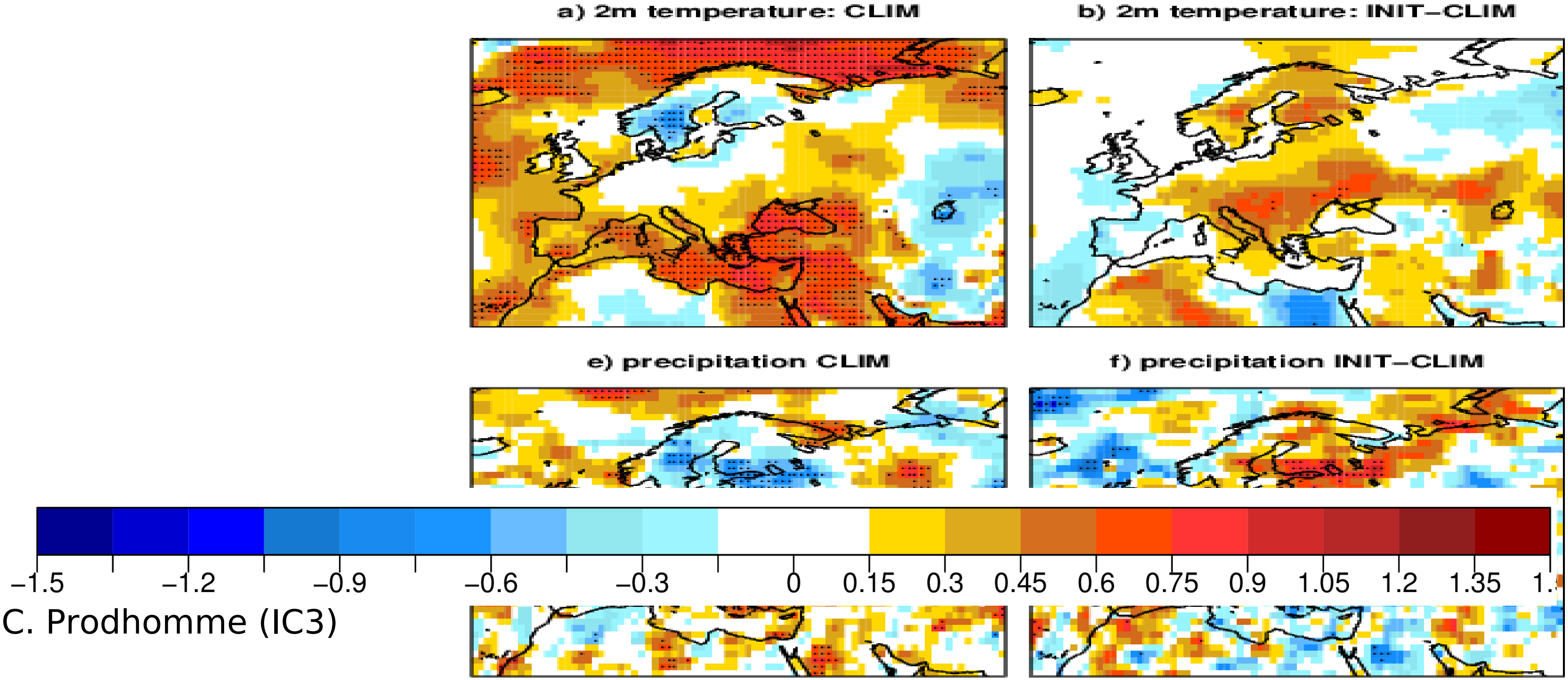




C. Prodhomme (IC3)

Impact of initialisation: Land surface

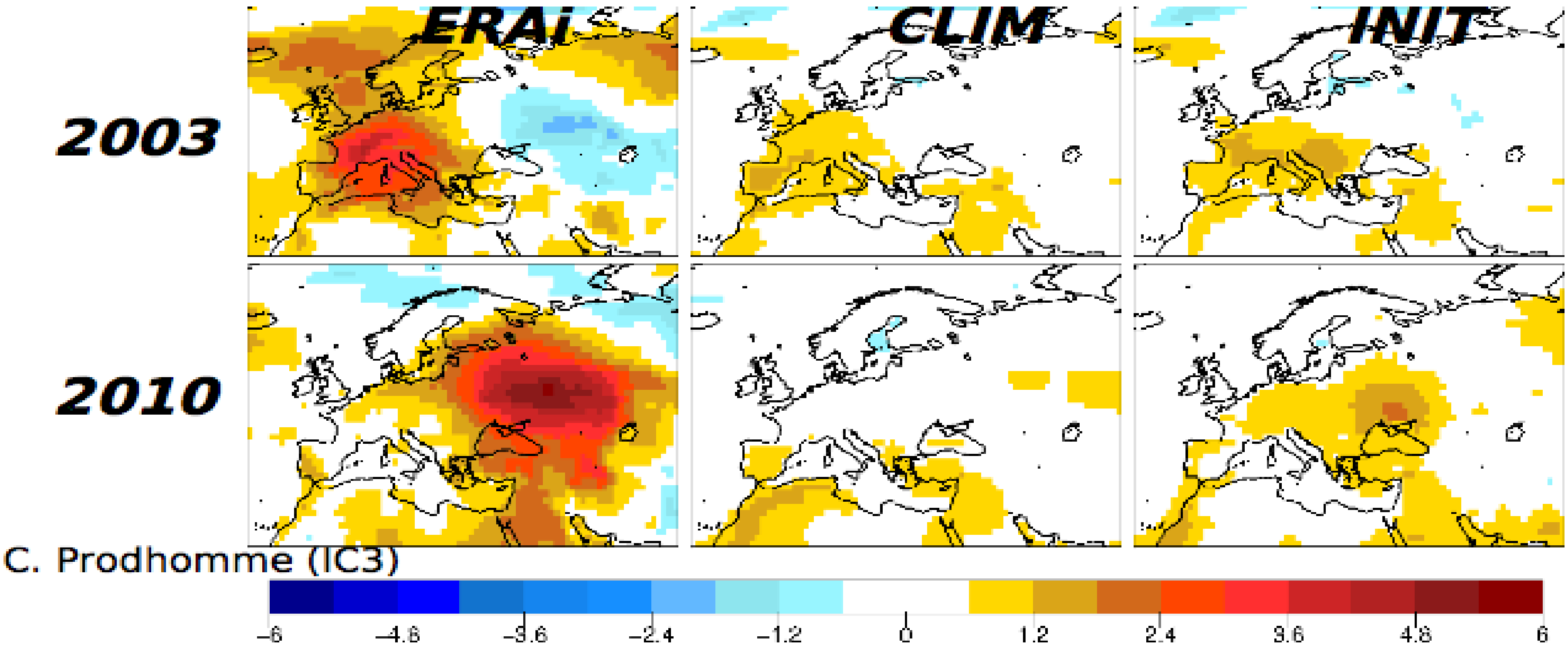
Difference in the correlation of the ensemble-mean near-surface temperature and precipitation from two experiments (JJA), one using a realistic and another a climatological land-surface initialisation. Results for EC-Earth2.3 started every May over 1979-2010 with ERAInt and ORAS4 initial conditions and a sea-ice reconstruction.



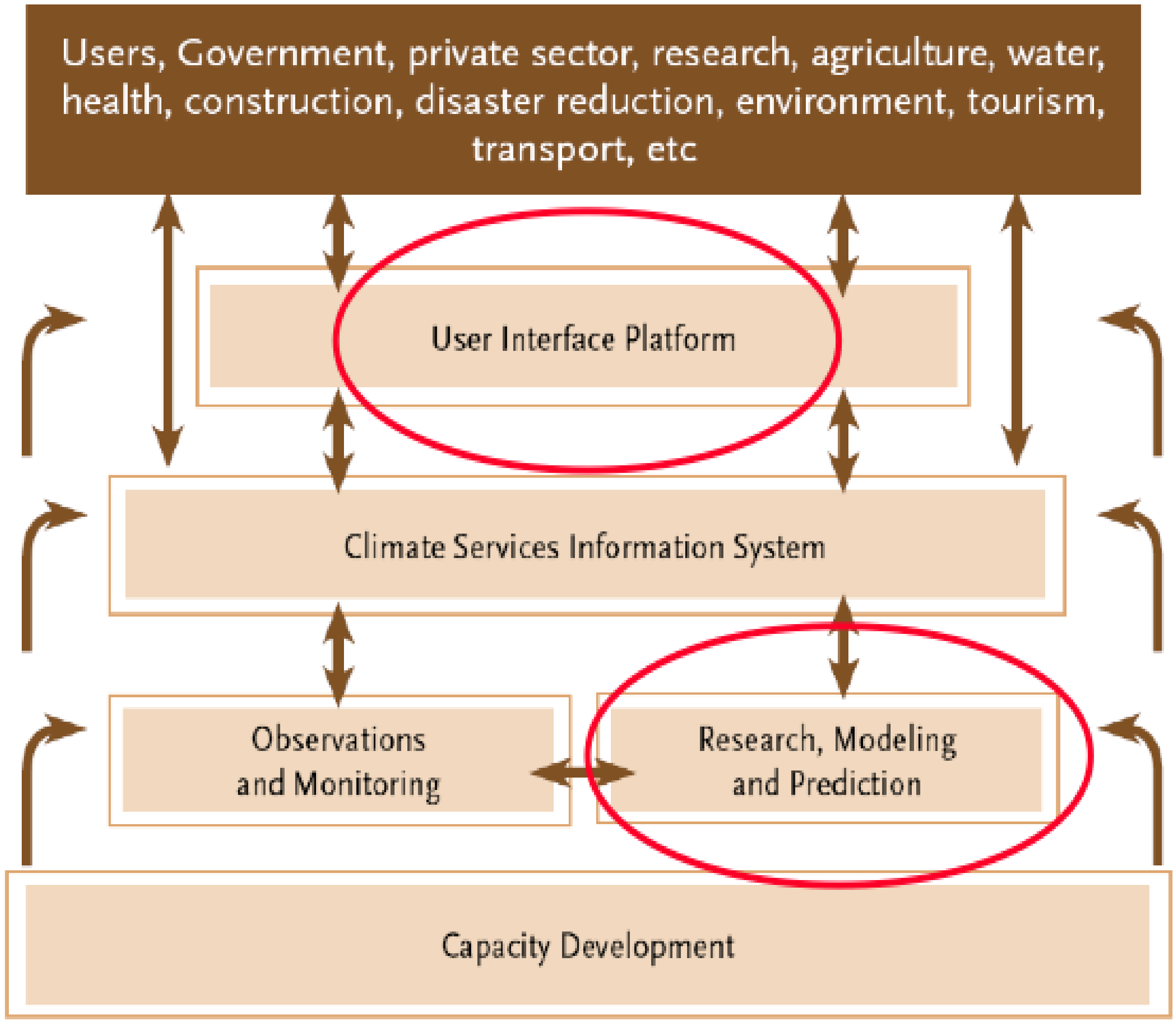
C. Prodhomme (IC3)

Impact of initialisation: Land surface

JJA precipitation in 2003 (top row) and near-surface temperature in 2010 (bottom row) anomalies from ERAInt (left) and experiments with a climatological (centre) and a realistic (right) land-surface initialisation. Results for EC-Earth2.3 started in May with initial conditions from ERAInt, ORAS4 and a sea-ice reconstruction over 1979-2010.



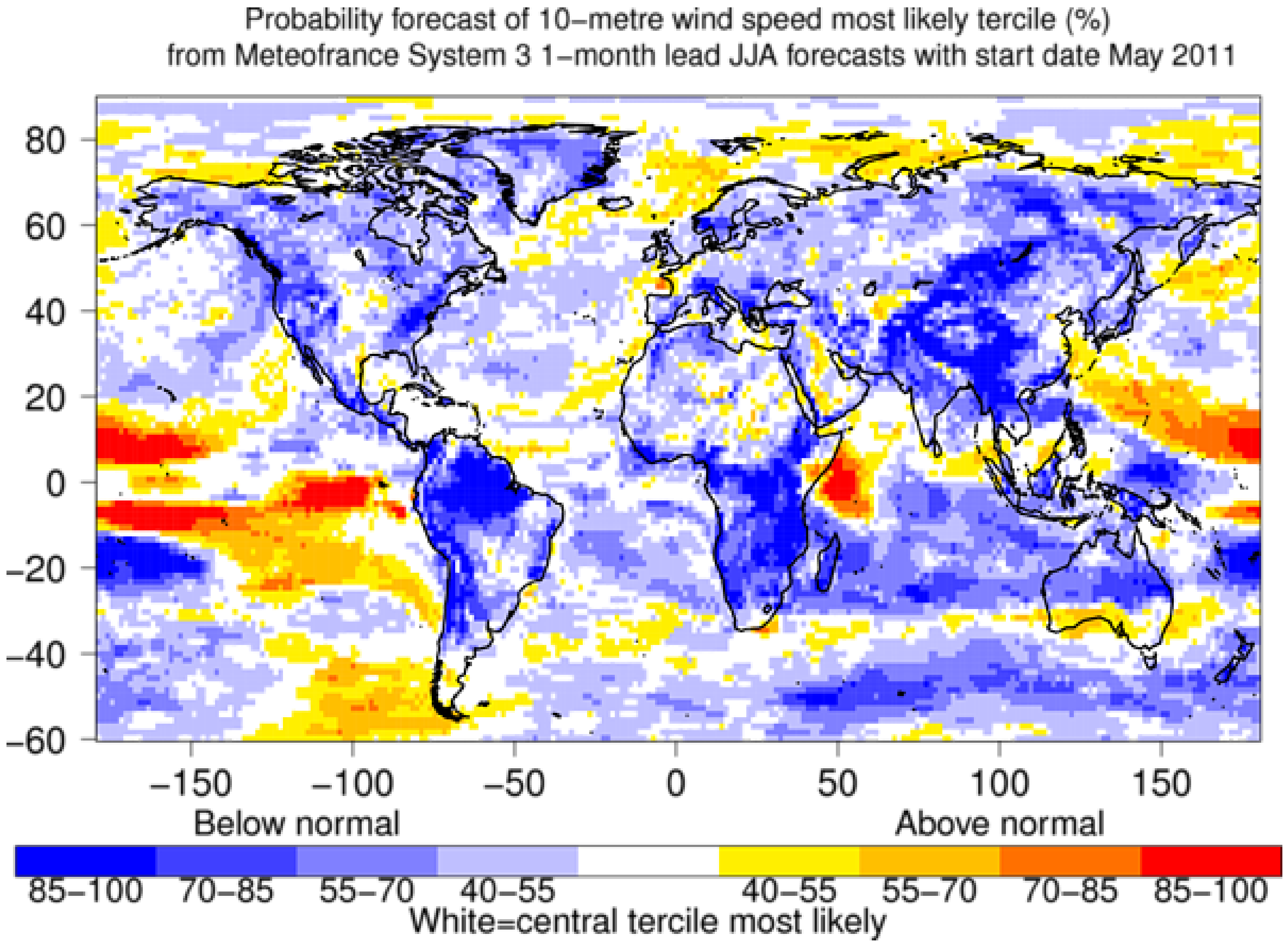
Global framework on climate services



Some of the things missing

- Understanding of the impact models, and the best way to adapt them to the useful climate information available
- Bias correction
- Calibration and combination
- Downscaling, when necessary
- Documentation (follow the IPCC calibrated language), demonstration of value and outreach
- The EUPORIAS project, working alongside SPECS, is considering solutions to address some of these problems.

Climate services: renewable energy

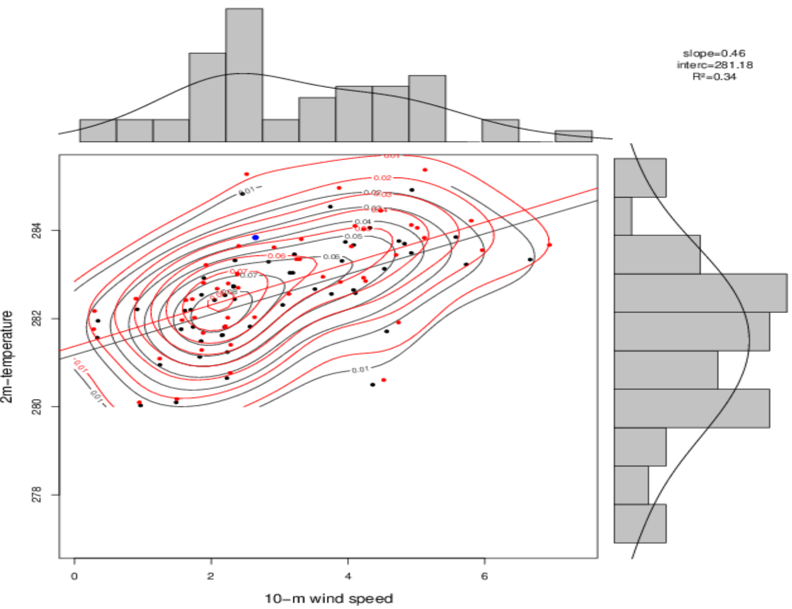


Lienert and Doblas-Reyes (2013)

Bias correction

Bias correction is necessary, but it can also impact the skill. Bias-corrected ECMWF S4 forecasts for November with start date in November over 1981-2012. One-year-out cross-validation applied.

Method 1: Simple

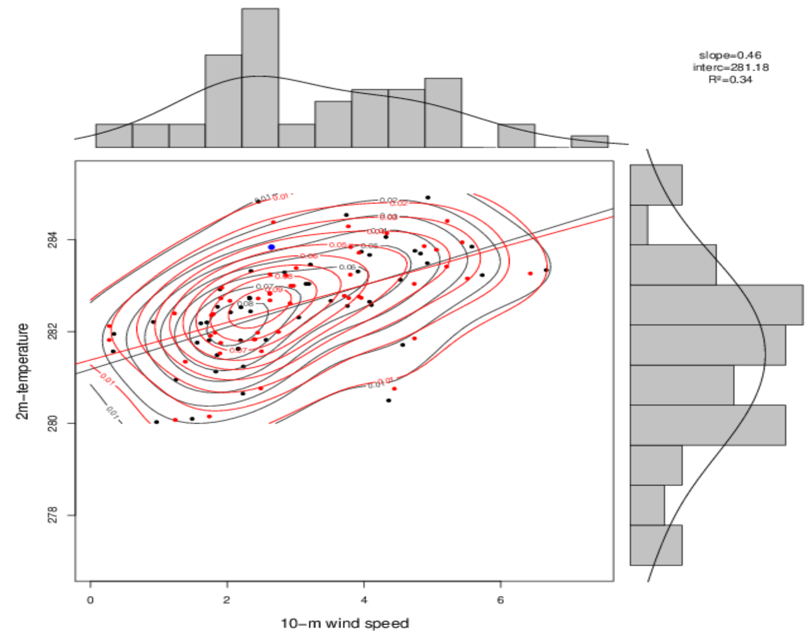


Forecast bias corrected

Forecast uncorrected

Observation

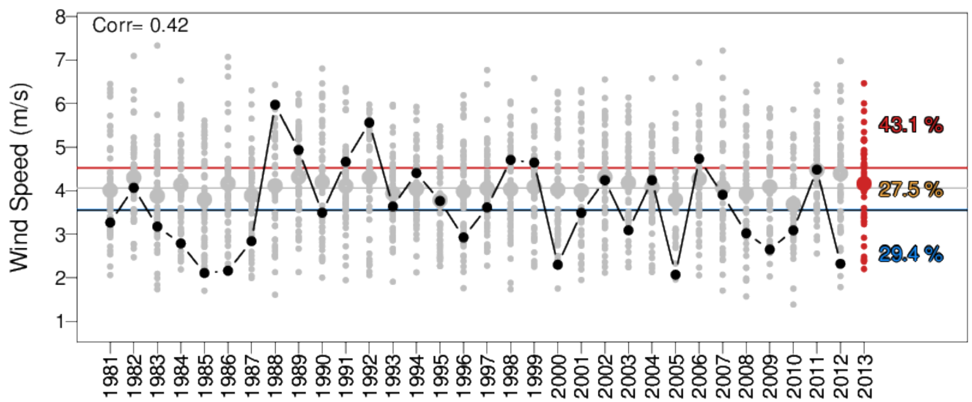
Method 2: Percentile Matching

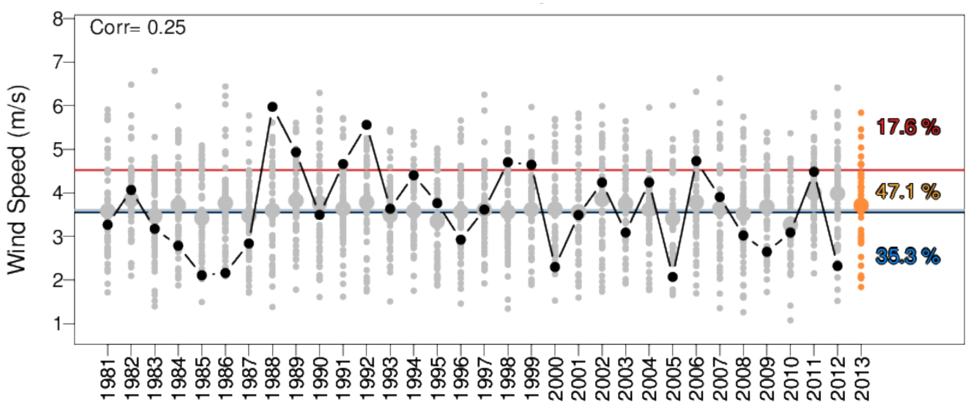


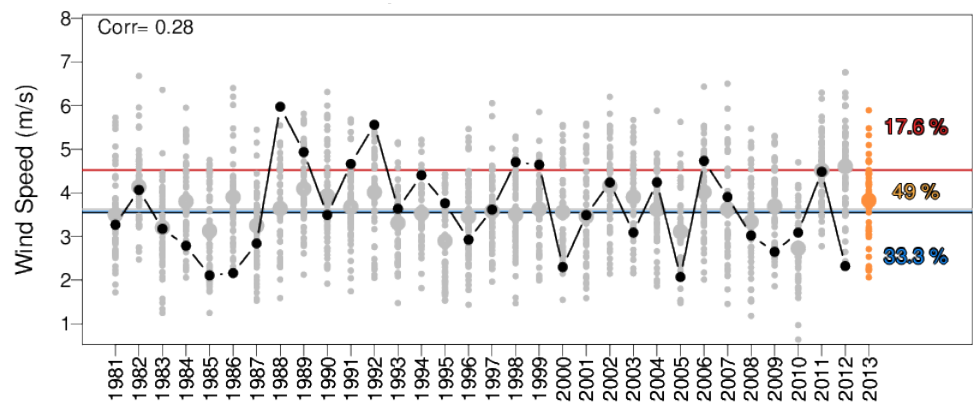
V. Torralba (IC3)

Bias correction and calibration

Bias correction and calibration have different effects. ECMWF S4 predictions of 10 m wind speed over the North Sea for DJF starting in November. Raw output (top), bias corrected (simple scaling, left) and ensemble calibration (right). One-year-out cross-validation applied.







V. Torralba (IC3)

Progress on the open fronts

- Work on initialisation: initial conditions for all components (including better ocean), better ensemble generation, etc. Link to observational and reanalysis efforts.
- Model improvement: leverage knowledge and resources from modelling at other time scales, drift reduction. More efficient codes and adequate computing resources.
- Calibration and combination: empirical prediction (better use of current benchmarks), local knowledge.
- Forecast quality assessment: scores closer to the user, reliability as a main target, process-based verification.
- Improving many processes: sea ice, projections of volcanic and anthropogenic aerosols, vegetation and land, …
- More sensitivity to the users' needs: going beyond downscaling, better documentation (e.g. use the IPCC language), demonstration of value and outreach.
- Estimation of uncertainty.
- Impact of aerosols (anthropogenic and volcanic).
- Interactive vegetation scheme.